Disking And Prescribed Burning For Loblolly Pine Regeneration

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ABSTRACT.—Disking and three summer prescribed burning series were compared in the Virginia coastal plain on the basis of cost and effectiveness in regenerating loblolly pine (*Pinus taeda* L.). Disking cost about four times more than the longest and most expensive series of summer prescribed burns. Seedling stocking was adequate for all site preparation treatments at 2 years, but significantly fewer seed were needed to produce one seedling in the three-summer-burn treatment than in any of the other treatments. The same treatment was also best in holding down crown coverage and size of the small hardwood competition. None of the treatments appeared to have a lasting effect on the shrub component of the understory vegetation.

LOBLOLLY PINE (*Pinus taeda* L.)—the top-ranking commercial timber species in the Southern United States and the second most important timber species in the world—is probably the South's greatest renewable resource. Because of its excellent regenerative characteristics, its competitive ability, its rapid growth, and its steady market demand, loblolly pine lends itself to intensive management, making it the leading tree in the South in this respect (*13*). Consequently, landowners managing this species are continually seeking cultural methods that either reduce costs, increase productivity, or perhaps do both. This paper reports on a study designed to evaluate several site treatment measures used in regenerating loblolly pine in the Virginia and Carolina coastal plain.

Past research has shown that seed germination of loblolly is best with a mineral soil seedbed (*4, 8*), and that loblolly stands in the coastal plain require some seedbed preparation for consistently successful natural regeneration (*11*). Reducing the size of shrubs and small and large hardwoods also lessens early competition and promotes rapid pine seedling growth (*14*). In the mid-1950's heavy equipment (largely heavy-duty disks) was widely and successfully used in the Virginia coastal plain to prepare sites for seeding and planting, but prescribed burning was not practiced in that area. Work in South Carolina by Chaiken (*2*) and Lotti (*5, 6*) showed that a series of fires—a winter fire followed by a succession of annual summer fires before the harvest cut—was effective in reducing understory hardwoods and shrubs and in preparing seedbeds for natural regeneration at a very low cost per acre. This suggested the need in Virginia for comparing disking and burning on a scale large enough to compare costs and the effectiveness of the two methods.

The Study

In 1955, eight 40-acre blocks of 60-year-old loblolly pines on the Camp Experimental Forest[1] were selected to study the effects of site preparation on regeneration and understory control. Four treatments, replicated twice, were imposed before logging:

1. One winter and one summer burn.
2. One winter and two annual summer burns.
3. One winter and three annual summer burns.
4. Disking with bush and bog harrow.

Winter burns were made in January or February, 1½ years before the first summer burn, and the summer burns in June or July. The treatments were scheduled so that the disking and final summer burns were

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[1] The Camp Experimental Forest, located in Sussex and Southampton Counties, Virginia, was maintained by the Southeastern Forest Experiment Station in cooperation with the Union Bag-Camp Paper Corporation, Camp Division, Franklin, Va. The authors gratefully acknowledge the manpower, equipment, and materials essential for the completion of this study that were furnished by the Union Bag-Camp Paper Corporation and the Virginia Division of Forestry, Waverly, Va.

accomplished just prior to the harvest cut (Fig. 1). The first replication of four treatments was cut to eight seed trees per acre in the period of June to September 1958, and the second replication was cut in the same period in 1959. Seed trees were removed 2 years later in the first replication and 3 years later in the second. Estimates of pine regeneration were made in the fall of 1960 and 1961 when seedling stands were 2 years old.

In each 40-acre treatment block, 10 ¼-milacre seedtraps and 100 one-milacre subplots were established to measure seedfall and pine stocking. In addition, 100 10-link transects per treatment block were established in the second growing season after logging at the milacre plot locations to estimate the crown coverage, defined as the percent of area occupied by hardwoods and shrubs, and the height of the tallest hardwood and shrub. The transects not disturbed by the logging of the seed trees were measured again 4 years from the time of initial seedling establishment.

Prior to the first burn, boundary and interior lines were plowed to subdivide each area into three or four smaller blocks. A four-disk Mathis plow with an HD-9 tractor was used for this fireline construction. The normal crew was one tractor operator and a supervisor. Before each summer burn, the exterior lines were maintained with a lighter two-disk fire plow. Interior lines were not maintained for the summer burning series.

As a result of these practices, winter fires were smaller and their fireline length per acre longer. Winter burns varied from 7 to 56 acres; summer burns from 15 to 254 acres. The average acre for a winter burn required 1.71 chains of constructed line and summer burns 1.35 chains of maintained line.

The burning procedure was to set the leeward side first, allowing the fire to back a safe distance. Where roads, wind direction, and other conditions permitted, head fires were the usual method. Crew size for burning varied from 3 to 8 persons. Average air temperature, relative humidity, windspeed, and fuel moisture were (*1*) during the winter burns: 50°F, 48 percent, 7 m.p.h., and 10 percent, and (2) during the summer burns: 86°F, 55 percent, 3 m.p.h., and 7 percent, respectively.

For the disking treatment, each area was single-disked using two large tractors (HD-9 or HD-11) with heavy bush and bog disks. A typical crew organization was two tractor drivers and one supervisor.

Treatment Costs

Records of time and cost of all site treatments were maintained. Analyses were made of the cost data, and a generalized cost estimate for each treatment was made assuming a five-man burning crew (four laborers and one supervisor), uniform labor cost, and no stand-by or transportation cost. A $12.00 per hour rate was used for all tractor work.

Estimated cost per acre was:

Operation	Cost per acre
Line construction	$ 1.04
Line maintenance	0.54
Winter burning and mop-up	1.20
Summer burning and mop-up	0.57
Disking	22.19

The figures show that line construction is more costly than line maintenance, and burning and mop-up costs are higher for winter than summer fires. The size of the average fire influences cost considerably. Small fires (under 30 acres) were the most costly, $1.50 to over $4.00 per acre; medium size fires (30 to 60 acres) were next, costing between $0.25 and $1.15 per acre; and large fires (over 100 acres) were least costly, averaging less than $0.30 per acre.

A

B

Fig. 1.—Hardwood and shrub understory in a loblolly pine stand on the Camp Experimental Forest *(A)* before site treatment, *(B)* immediately following the third annual summer burn treatment.

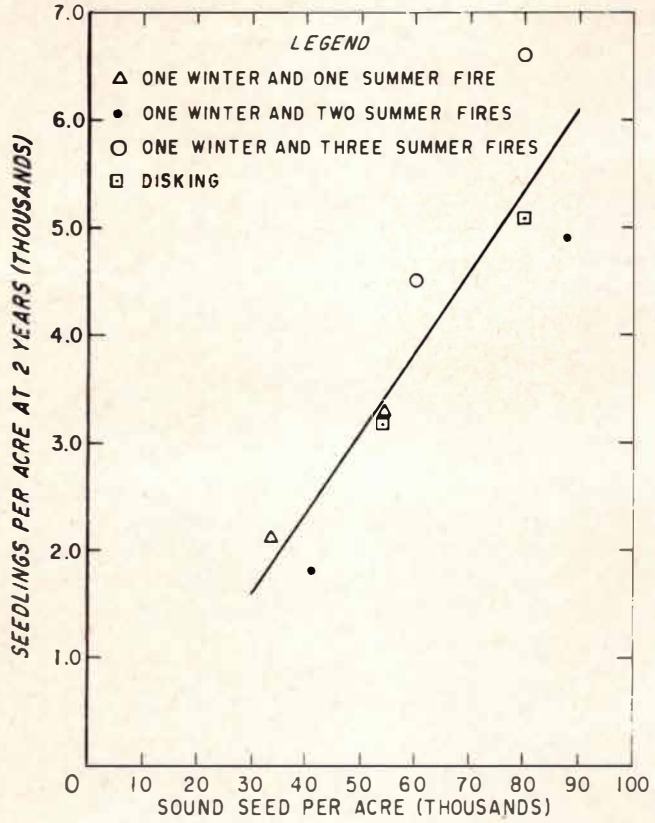

Fig. 2.—Relationship between sound seed and seedling stocking at 2 years after the harvest cut.

Average cost per acre for the four treatments was:

Treatment	Cost per acre
Winter and one summer fire	$ 3.35
Winter and two summer fires	4.46
Winter and three summer fires	5.57
Disking	22.19

Included in the burning cost are the initial fireline construction ($1.04), the winter burn ($1.20), fireline maintenance before each summer burn ($0.54), and the summer burn ($0.57). Disking required about 1.85 tractor hours per acre.

Disking was about four times more expensive than the most costly series of burning treatments and over six times more expensive than the minimum burning treatment tested.

Table 1.—Sound Seed Needed to Produce One Seedling at End of the Second Growing Season

Treatment	Sound seed
	Number
Winter and one summer fire	17.2
Winter and two summer fires	18.9
Winter and three summer fires	12.8
Disking	16.2
Least significant difference at 5 percent level	1.2

Treatment Effects

Site treatments were evaluated in terms of loblolly pine stocking and the crown coverage and height of small hardwoods and shrubs. Stocking was considered an indirect measure of the receptiveness of the seedbed to pine regeneration; crown coverage and height of small hardwoods and shrubs a measure of competition. Both are used as indices of the effectiveness of the site preparation treatments.

Seedling stocking.—Seedling stocking at 2 years was adequate for all site treatments (Fig. 2). The lowest stocking on any treatment block was 1,800 seedlings per acre, and the lowest milacre stocking (milacre plots with one or more seedlings) was 62 percent. Because of the high correlation ($r = 0.906$) of seedfall with stocking, two analyses were made, a covariance analysis with number of sound seed as the covariant and an analysis of variance with the ratio of seeds to seedling as a variable. Both led to the same conclusions, and only the latter is presented (Table 1). This analysis showed that it took fewer seed to produce one seedling in the three-summer-burn treatment than it did in any other treatment. The one-summer-burn was not significantly different from the disking treatment, and the two-summer-burn was the poorest. The poor showing of this last treatment is due, at least in part, to incomplete burning coverage of one of the blocks because of excessive moisture. Twenty-nine percent of that block had no evidence of being burned and an undetermined portion received only very light fires.

Table 2.—Crown Coverage and Height of Small Hardwoods and Shrubs 2 and 4 Years after Site Preparation

Treatment	Crown coverage		Total height	
	2 years	4 years	2 years	4 years
	Percent		*Feet*	
A. Small hardwoods				
Winter and one summer fire	14.8	20.2	3.8	5.5
Winter and two summer fires	12.0	17.5	4.1	4.4
Winter and three summer fires	5.6	9.4	2.9	3.2
Disking	9.0	14.0	3.6	5.0
Least significant difference at the 5-percent level	7.1	6.9	1.3	0.3
B. Shrubs				
Winter and one summer fire	—	56.0	1.8	2.5
Winter and two summer fires	—	40.6	1.4	2.3
Winter and three summer fires	—	29.5	1.5	1.9
Disking	—	46.2	1.9	2.2
Least significant difference at the 5-percent level	—	33.2	0.4	1.4

Small hardwoods and shrubs.—Two years after site treatment, the average crown coverage of small hardwoods on all plots was only 10.4 percent; the one-summer-burn plots, with 14.8 percent coverage, had significantly more small hardwoods than three-summer-burn plots with 5.6 percent of the area occupied (Table 2). After 4 years the same trends between treatments were still evident, but average crown coverage had increased to 15.3 percent. After 4 years the three-summer-burn treatment had held the coverage of small hardwoods in check significantly better than had the one- or the two-summer-burns. None of the other treatment comparisons for coverage of small hardwoods were significantly different.

Differences in height of the tallest hardwoods were quite variable. They were not significant at 2 years, but by 4 years a significant trend was evident (Table 2); each additional summer burn apparently reduced the vigor of the rootstalk which was reflected in the height of the tallest hardwood at 4 years. The disking treatment ranked third in holding the small hardwoods in check, and was superior only to the one-summer-burn treatment in this respect.

Differences related to treatment were barely significant for shrub height at 2 years and by 4 years they were insignificant. The crown coverage of the shrub component was not measured at 2 years, but 4 years after the site treatments, it averaged 43 percent, with no significant difference in treatment. When compared with an average shrub coverage of 58 percent before the site preparation, it appears that none of the treatments had a lasting effect on the area occupied by the shrub community.

Discussion

Rothkugel (*10*) was probably the first American forester to recognize the beneficial effects of fire and to advise its use in regenerating loblolly pine in South Carolina. Rothkugel's specific recommendation was a winter burn preceding the harvest cut, followed after logging by a fire to burn the logging slash. Ashe (*1*) was also among the early foresters who recommended burning after logging, but probably the strongest supporter was Chapman (*3*) who advocated a post-logging fire to consume the slash and litter, to kill back advance growth of hardwood brush, and to expose mineral soil for a seedbed. Trousdell (*12*), in a study on Bigwoods Experimental Forest in North Carolina, compared the effectiveness of a "Chapman-type" burn with no site treatment other than logging and with disking prior to logging. He found that a post-logging fire improved stocking at about the same level as the disking. Burning cost was $2.57 per acre, compared to disking at $19.42 per acre, a cost comparison very similar to this study.

Unlike the work by Rothkugel, Ashe, and Chapman, the tests reported here were summer burns in a mature loblolly stand prior to harvest cuts and were similar to those described by Chaiken (*2*), Lotti (*5, 6*), and Lotti et al. (*7*). Our results confirmed the recommendations of Lotti et al. (*7*) that depending on the species composition, 2 to 4 annual summer fires were needed for satisfactory levels of understory control. Our costs of burning were higher ($2.24 per acre for the initial winter burn and $1.11 for each succeeding summer burn) than those of Lotti and his coworkers (average of $0.46 per acre) or of Riebold (*9*) that were $0.22 per acre. However, on-the-ground conditions, size of fire, and equipment needed to plow firelines all vary from area to area, and consequently affect costs.

The effectiveness of the three summer burns in holding the hardwoods in check for 4 years as well as or better than any of the other treatments is significant because it is the period when future stand composition is largely determined. The rate of hardwood height growth is greater during this period than it is in later years (*14*), and thus any reduction in small hardwood growth tends to favor the pine.

Conclusions

The results of this study lead to the conclusion that although each treatment was effective, a winter prescribed burn followed by three summer prescribed burns was consistently the most effective method of preparing the seedbed for loblolly pine regeneration and in controlling and holding the hardwood component in check up to 4 years. Cost comparisons—even including the longest series of burning treatments—favored burning over disking.

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